make with ICs
DIGITAL CAR CLOCK
put it anywhere
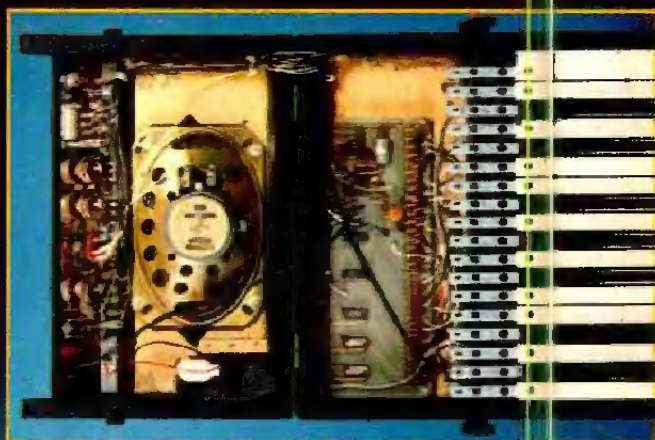
5 full octaves
KEYBOARD SYNTHESIZER
you can build

General Instrument
IC DATA SHEET
for video games

how we check
NOISE MEASUREMENTS
in hi-fi gear

all about
ANALOG MULTIMETERS
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ic application of the month

Application notes are hard to get unless you are an engineer. So we've decided to try an experiment and select and publish some interesting ones in **Radio-Electronics**. We're starting with this TV Game IC from General Instruments. If you find this one of interest and want more, let us know by circling #105 on the Free Information Card. If you think it's a waste of space, tell us that by circling #110 on the Free Information Card.

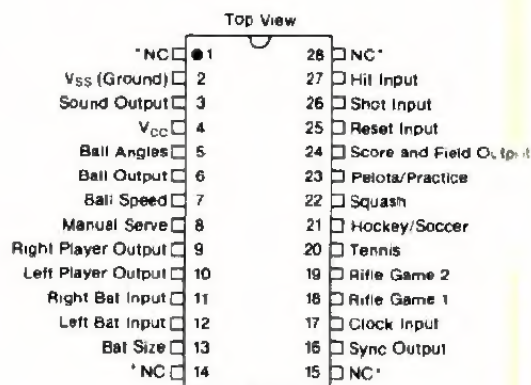## AY-3-8500   TV GAME

FEATURES

- 6 Selectable Games - Tennis, hockey/soccer, squash, pelota/practice and two rifle shooting games.
- 625 Line (AY-3-8500) and 525 Line (AY-3-8500-1) versions.
- Automatic Scoring
- Score display on T.V. Screen, 0 to 15.
- Selectable Bat Size
- Selectable Angles
- Selectable Ball Speed
- Automatic or Manual Ball Service
- Realism Sounds
- Shooting Forwards in Hockey Game
- Visually defined area for all Ball Games.

DESCRIPTION

The AY-3-8500 and AY-3-8500-1 circuits have been designed to provide a TV 'games' function which gives active entertainment using a standard domestic television receiver.
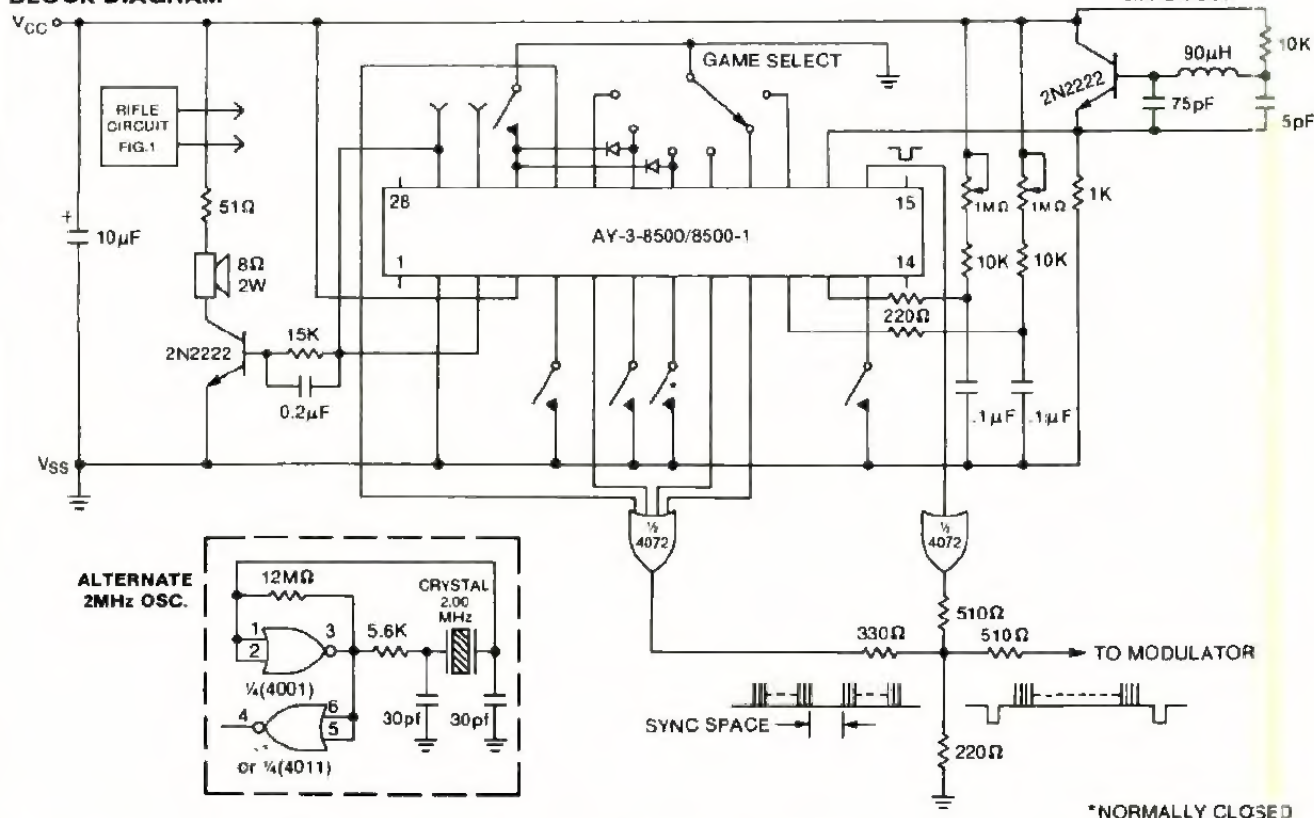
The circuit is intended to be battery powered and a minimum number of external components are required to complete the system. A block diagram is shown below.

PIN CONFIGURATION
28 LEAD DUAL IN LINE

Top View

*NC	1	28	NC*
V$_{SS}$ (Ground)	2	27	Hit Input
Sound Output	3	26	Shot Input
V$_{CC}$	4	25	Reset Input
Ball Angles	5	24	Score and Field Output
Ball Output	6	23	Pelota/Practice
Ball Speed	7	22	Squash
Manual Serve	8	21	Hockey/Soccer
Right Player Output	9	20	Tennis
Left Player Output	10	19	Rifle Game 2
Right Bat Input	11	18	Rifle Game 1
Left Bat Input	12	17	Clock Input
Bat Size	13	16	Sync Output
*NC	14	15	NC*

*Do not use as tie point

BLOCK DIAGRAM

*NORMALLY CLOSED

1) Tennis

With the tennis game the picture on the television screen would be similar to Figure 2 with one 'bat' per side, a top and bottom boundary and a center net, the individual scores are counted and displayed automatically in the position shown. The detail of the game will depend upon the selection of the options. Considering the situation where small bats are used and all angles, after the reset has been applied, the scores will be 0, 0 and the ball will serve arbitrarily to one side at one of the angles. If the ball hits the top or bottom boundary it will assume the angle of reflection and continue in play. The player being served must control his bat to intersect the path of the ball. When a 'hit' is detected by the logic, the section of the bat which made the hit is used to determine the new angle of the ball.

To expand on this, all 'bats' or 'players' are divided logically into four adjacent sections of equal length. When using the four angle option it is the quarter of bat which actually hits which defines the new direction for the ball.

The direction does not depend upon the previous angle of incidence. With the two angle option the top and bottom pairs of the bats are summed together and only the two shallower angles are used to program the new direction for the ball.

The ball will then traverse towards the other player, reflecting from the top or bottom as necessary until the other player makes their 'hit'. This action is repeated until one player misses the ball. The circuitry then detects a 'score' and automatically increments the correct score counter and updates the score display. The ball will then serve automatically from the center line towards the side which had just missed. This sequence is repeated until a score of 15 is reached by one side, whereupon the game is stopped. The ball will still bounce around but no further 'hits' or 'scores' can be made. While the game is in progress, three audio tones are output by the circuit to indicate top and bottom reflections, bat hits and scores.

2) Hockey/Soccer

The 'hockey' type game is shown in Figure 3, and with this game each participant has a 'goalkeeper' and a 'forward'. The layout is such that the 'goalkeeper' is in his normal position and the 'forward' is positioned in the opponent's half of the playing area.

When the game starts, the ball will appear travelling from one goal line towards the other side. If the opponent's forward can intercept the ball, (Figure 3a), he can 'shoot' it back towards the goal. If the ball is missed it will travel to the other half of the playing area and the first team's forward will have the opportunity of intercepting the ball and redirecting it forward at a new angle according to the 'player' section which is used, (Figure 3b). If the ball is 'saved' by the 'goalkeeper' or it reflects back from the end boundary, the same forward will have the opportunity to intercept the outcoming ball and divert it back towards the 'goal'.

A 'score' is made in the 'hockey' game by 'shooting' the ball through the defined goal area. The scoring and game control is done automatically as for the tennis game. The same audio signals are used to add atmosphere to the game.

3) Squash

This game is illustrated in Fig.4. There are two players who alternately hit the ball into the court. The right hand player is the one that hits first, it is then the left hand player's turn. Each player is enabled alternately to insure that the proper sequence of play is followed.
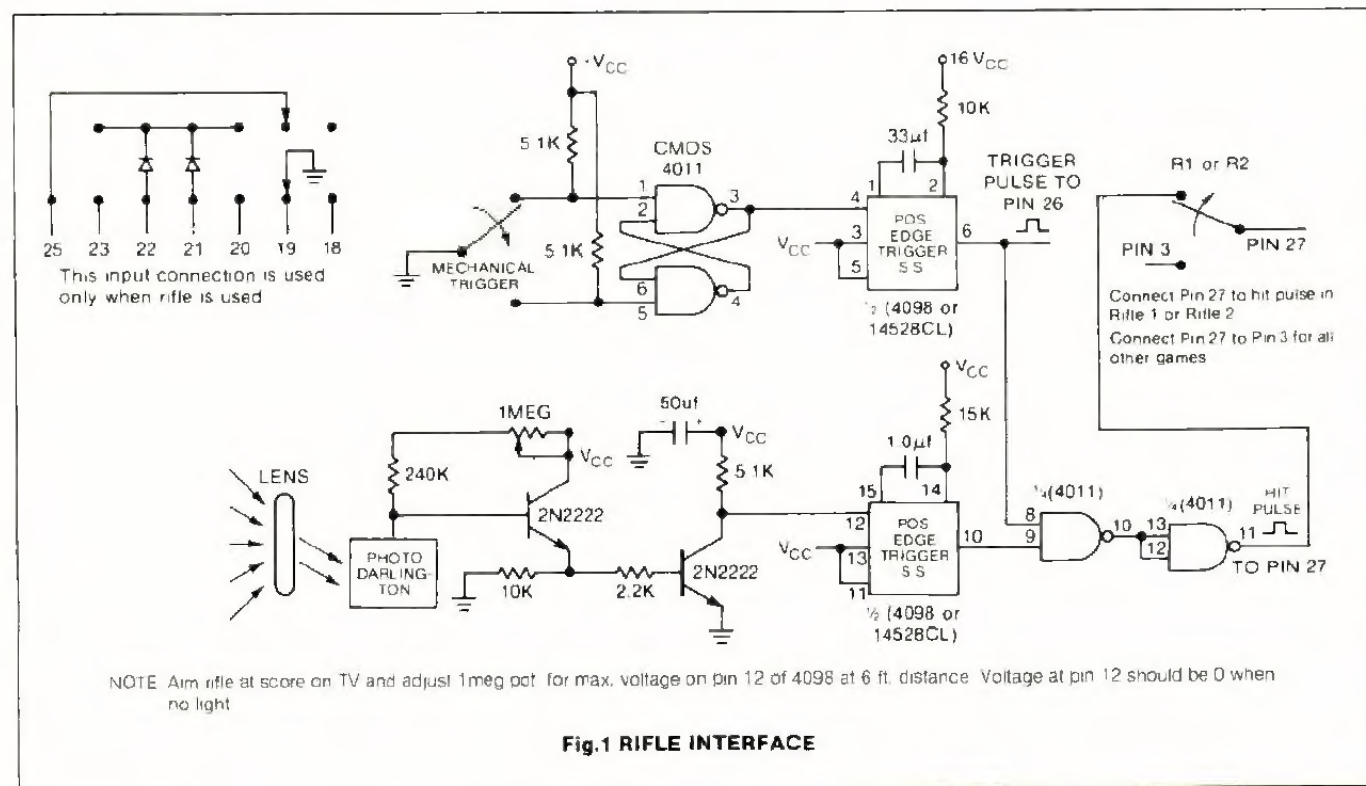
4) Pelota/Practice

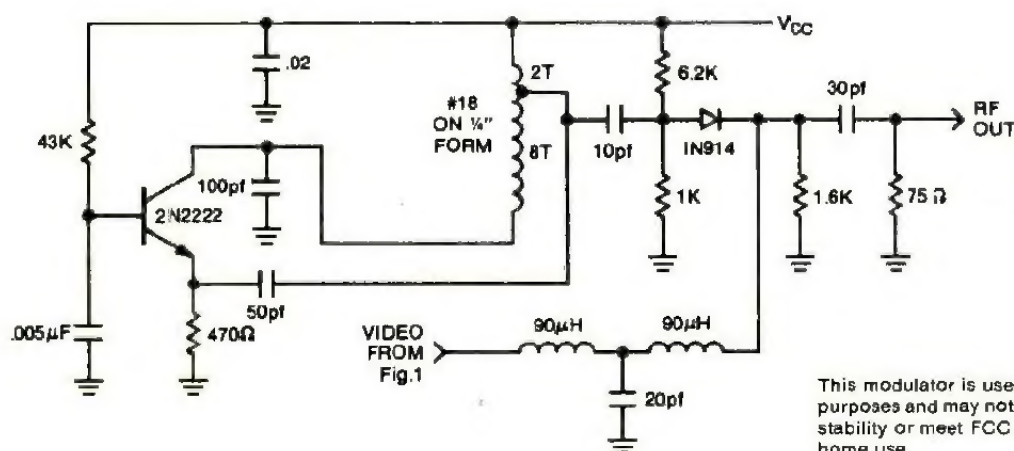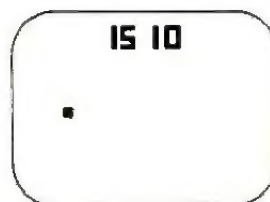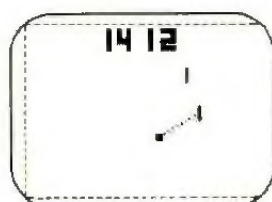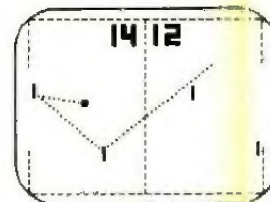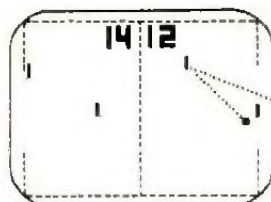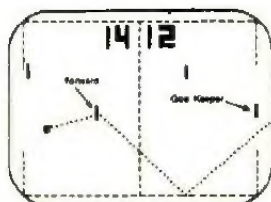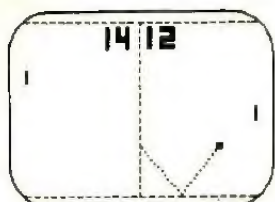This game is similar to squash except that there is only one player

5) Rifle Shooting

This game is illustrated in Fig.5. It has a large target which bounces randomly about the screen, a photocell in the rifle is aimed at the target. When the trigger is pulled the shot counter is incremented, if the rifle is on target the hit counter is incremented, a hit noise is generated and the target is blanked for a while. After 15 shots the score appears but the game can still continue.

6) Rifle Game No. 2

In this game the ball traverses the screen from left to right under control of the manual serve button. Otherwise the game is as above.

NOTE Aim rifle at score on TV and adjust 1meg pot for max. voltage on pin 12 of 4098 at 6 ft. distance Voltage at pin 12 should be 0 when no light

Fig.1 RIFLE INTERFACE

Fig.2 TENNIS GAME

Fig.3 HOCKEY GAME

Fig.3a RETURN OF 'GOAL SAVE'
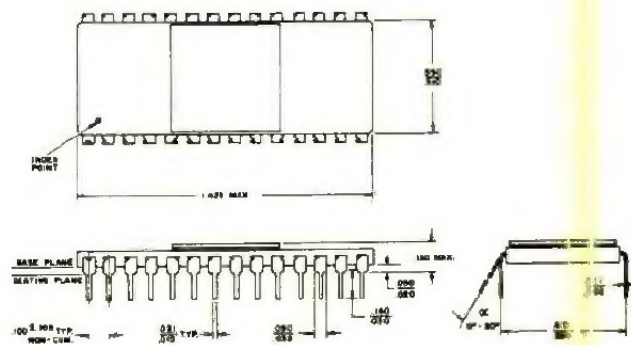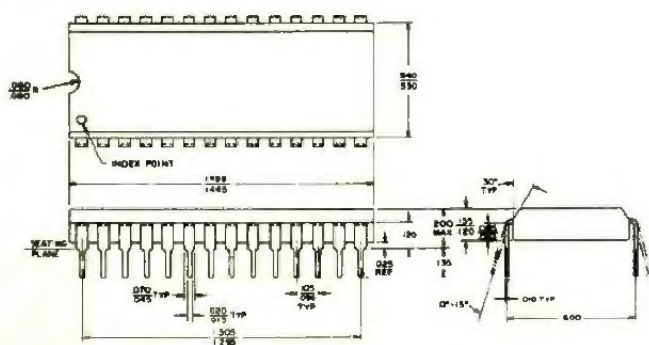

Fig.3b 'SHOOTING' FORWARD

Fig.4 SQUASH

Fig.5 RIFLE SHOOT

This modulator is used in the lab for test purposes and may not possess the long term stability or meet FCC requirements for home use.

Fig.6 VHF MODULATOR

PACKAGE OUTLINES

28 LEAD DUAL IN LINE

PLASTIC

CERAMIC

PIN FUNCTIONS

Left Bat Input
Right Bat Input
An R-C network connected to each of these inputs controls the vertical position of the bats. Use a 10K resistor in series with each pot.

Reset
This input is connected momentarily to V_{SS}(Logic '0') to reset the score counter and start a game.

Bat Size
This input is left open circuit (Logic '1') to select large bats and connected to Vss (Logic '0') to select small bats. For a 19" T.V. screen, large bats are 1.9" and small bats are 0.95" high.

Ball Angles
This input is left open circuit (Logic '1') to select two rebound angles and connected to V_{SS} (Logic '0') to select four rebound angles. When two angles are selected they are $\pm 20°$, when four are selected they are $\pm 20°$ and $\pm 40°$.

Ball Speed
When this input is left open-circuit, low speed is selected (1.3 seconds for ball to traverse the screen). When connected to V_{SS} (Logic '0'), the high speed option is selected (0.65 seconds for ball to traverse the screen).

Tennis, Hockey/Soccer, Squash, Pelota/Practice, Rifle Game 1 and Rifle Game 2
These inputs are normally left open circuit (Logic '1') and are connected to Vss (Logic '0') to select the desired game.

Manual Serve
This input is connected to V_{SS} (Logic '0') for automatic serving. When left open circuit (Logic '1') the game stops after each score. The serve is indicated by momentarily connecting the input to to V_{SS}.

Shot Input
This input is driven by a positive pluse output of a monostable to indicate a "shot".

Hit Input
This input is driven by a positive pulse output of a monostable which is triggered by the shot input if the target is on the sights of the rifle.

Sound Output
The hit (32ms pulse/976Hz tone), boundary reflection (32ms pulse/488Hz tone) and score (32ms pulse/1.95Hz tone) sounds are output on this pin.

Sync Output
The T.V. vertical and horizontal sync signals are output on this pin.

Ball Output
The ball video signal is output on this pin.

Score and Field Output
The score and field video signals are output on this pin.

Left Player Output/Right Player Output
The video signals for the left and right players are output on separate pins.

Note: The "Shot" and "Hit" inputs have on-chip pull-down resistors to V_{SS}. All other inputs (except the "Bat" inputs) have on-chip pull-up resistors to V_{CC}.

ELECTRICAL CHARACTERISTICS

Maximum Ratings*

Voltage on any pin with respect to V_{SS} pin . . . . . -0.3 to +12V
Storage Temperature Range . . . . -20°C to +70°C
Ambient Operating Temperature Range . . . . 0°C to +40°C

*Exceeding these ratings could cause permanent damage. Functional operation of these devices at these conditions is not implied —operating ranges are specified below.

Standard Conditions (unless otherwise noted)

V_{CC} = +6 to +7V   Operating Temperature (T_A) = 0°C to +40°C
V_{SS} = 0V   F Clock = 2.01 MHz ±1%

Characteristics at 25°C and V_{CC} = +6 Volts	Min	Typ	Max	Units	Conditions
Clock Input					Maximum clock source impedance
Frequency	1.99	2.01	2.03	MHz	of 1K to V_{CC} or V_{SS}.
Logic '0'	0	—	0.5	Volts	
Logic '1'	V_{CC}-2	—	V_{CC}	Volts	
Pulse Width —Pos.	—	200	—	ns	
Pulse Width — Neg.	—	300	—	ns	
Capacitance	—	10	—	pF	V_{IN} = OV, F = 1MHz
Leakage	—	100	—	µA	V_{IN} = +9.5V
Control Inputs					Max. contact resistance of 1K to V_{SS}
Logic '0'	0	—	0.5	Volts	
Logic '1'	V_{CC}-2	—	V_{CC}	Volts	Inputs have 100KΩ pull up to V_{CC}
Input Impedance	—	1.0	—	M Ohms	Pull up to V_{CC}
Rifle Input	—	1.0	—	M Ohms	Pull down to V_{SS}
Outputs					
Sync. Logic '0'	—	—	1.0	Volt	1 out = 0.5mA
Logic '1'	V_{CC}-2	—	—	Volts	1 out = 0.1mA
Ball. Logic '0'	—	—	1.0	Volt	1 out = 0.5mA
Logic '1'	V_{CC}-2	—	—	Volts	1 out = 0.1mA
Sound					
Logic '0'	—	—	1.0	Volts	1 out = 0.5mA
Logic '1'	V_{CC}-2	—	—	Volts	1 out = 50µA
Power Supply Current	—	50	—	mA	

COLOR OPTION

This option (the circuit is shown in the diagram immediately below) allows for the display of the various games in full color with different colors defining the playing area, team players, ball, boundaries, net and score.

The color application diagram is broken up into six sections, a main clock generator, a color burst locator, a phase angle generator, a phase angle multiplexer, a luminance multiplexer, and a summing network.

The main clock generator produces the 3.579 MHz clock for all the color clocks used and a 2.045 MHz clock for the chip clock. It includes 3 CMOS packages and a 3.579 MHz crystal.

The color burst locator produces the time slot after the sync pulse, being initiated from the AY-3-8500, for a period of 11 cycles of the color frequency, approximately 3.1 μs.

The phase angle generator produces the phase angles for all the colors used. It consists of a single CMOS package of inverters. These inverters produce phase angles, approximately 135° away from their inputs.

The phase angle multiplexer feeds the correct angle for each output from the game circuit into the summing network. This section consists of a single MOS multiplexer package.

The luminance level multiplexer produces the proper DC level for any given color so that the color is of the correct intensity. Also included is the logic necessary for generating the background timing and color. This consists of a MOS multiplexer package and two CMOS packages.

The summing network combines all the DC and AC signals without distorting their levels into a single output for RF modulation at TV receiver frequency. This section consists of 3 n-channel FET's and assorted resistors and capacitors.
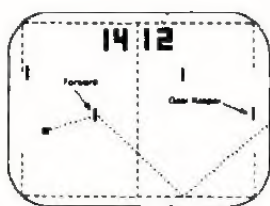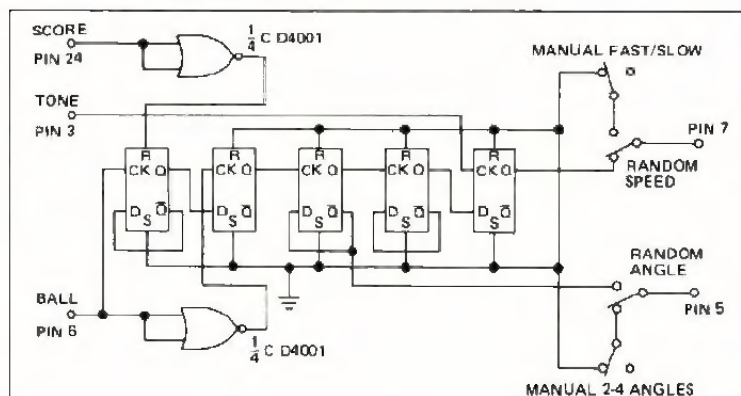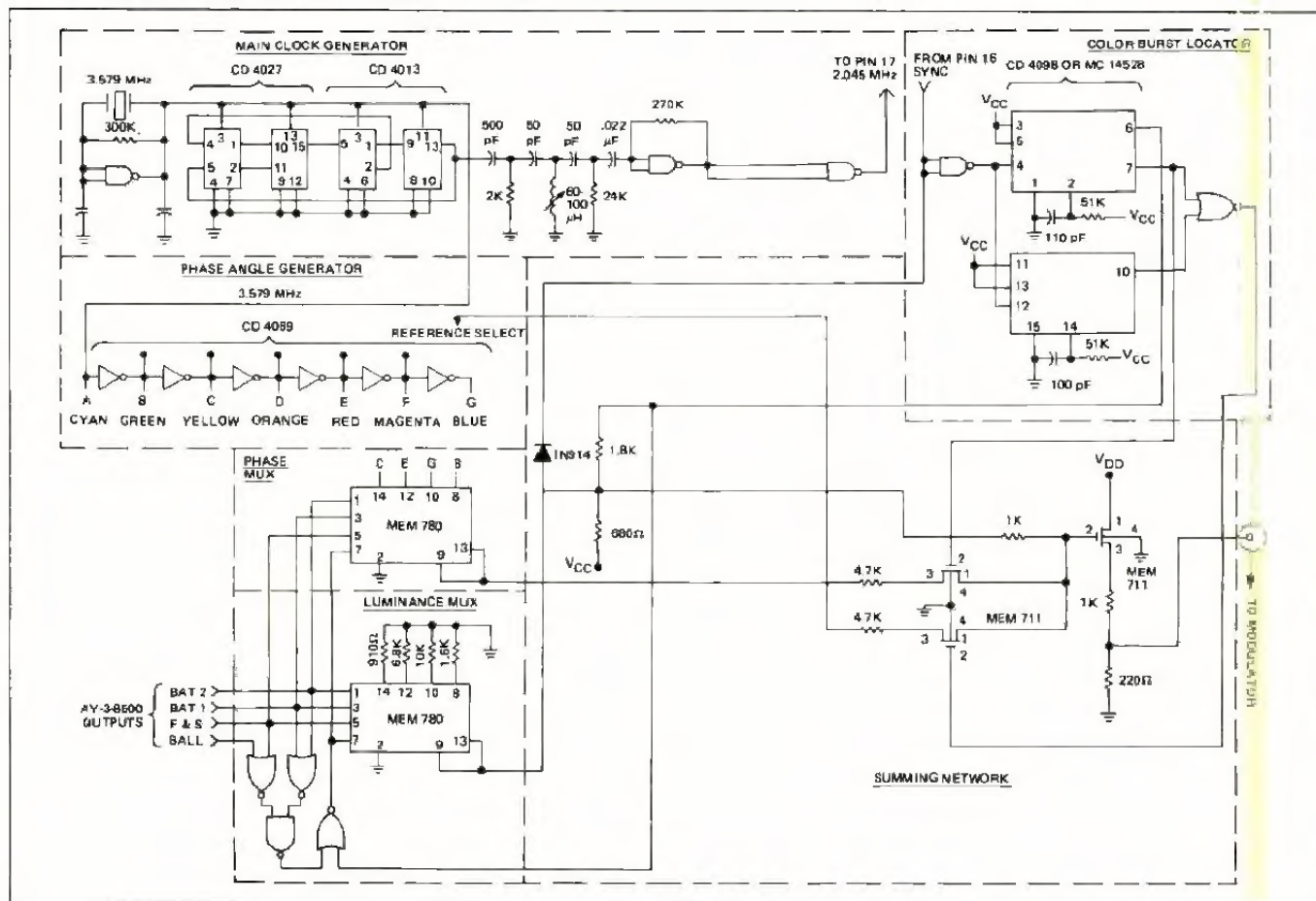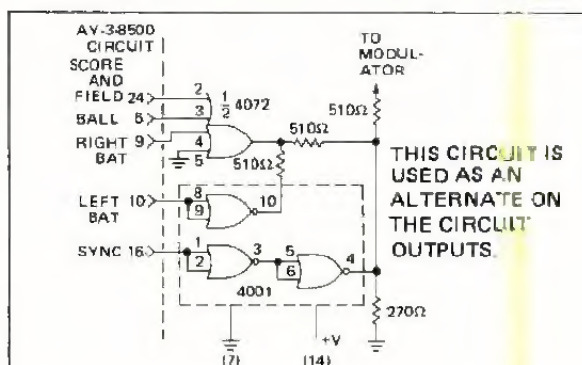

Fig.3 HOCKEY GAME

To enhance the excitement and challenge of the TV games, this option provides random variations of the ball speed and random changes in the ball rebound angle as the games are being played.

This option provides an added factor for player team recognition. The field or court is produced as a gray background with the bats in black and white. This option is particularly helpful for the squash game where the players are positioned close together.